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DEPENDENCE PARAMETERS ON DIELECTRIC BEHAVIOR OF MO^{6+} SUBSTITUTED LITHIUM FERRITES

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ABSTRACT

High variance Mo^{6+} substituted lithium ferrite with general formula [Li $_{(1+3y)/2}$Mo$_y$Fe$_{2.5-5y/2}$] O$_4$: where y=0.05 to 0.5 in steps of 0.05 were prepared under solid- state reaction method sintered at high temperature 1200^{o}C. The dielectric behavior of all the samples was studied from 50 -10^{6}Hz. The dielectric constant initially increases at y=0.10 then decreases to y=0.15 then increases up to y = 0.25 from where maintains constant up to y=0.40 then decreases finally with increasing compound which is due to space charge polarization. The dielectric constant shows a similar behavior with frequency variations and dielectric constant values lie in between 55-60 at MHz frequencies this is also due to the reduction of Fe^{3+} to Fe^{2+}. The dielectric loss is a very low value (below1) at high frequencies due to hopping frequency.

***KEYWORDS**: Lithium Ferrites, Dielectric Behavior& Conduction Mechanism*

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Original Article

INTRODUCTION

Ferrites are an important class of ceramic magnetic materials especially lithium ferrites are potential materials in science and technology due to the reasons of highest Curie temperature T_c (no other ferrites has such Curie temperature greater than this T_c), Excellent rectangular loop characteristics, high resistivity, low eddy current losses, superior temperature stability of saturation magnetization, low intrinsic line width and low magnetic losses, low intrinsic line width and low magnetic losses, dielectric properties resembles with that of microwave ferrites, excellent flat profile at high frequencies, low dielectric loss, and high Neel Temperatures, properties rapidly change with variation in composition, high dielectric constant, low- stress sensitivity of remanance [1-5]. Lithium ferrites [$Li_{0.5}$ $Fe_{2.5}O_4$] belongs to inverse spinel ferrites with face- centered cubic structure contains 'A' site (64 tetrahedral sites) and 'B' sites (32 octahedral sites) totally contains 96 interstitial sites. All Li^{1+} ion and Fe^{3+} ion occupies 'B' site and remaining all Fe^{3+} ion occupies 'A' site. Site occupation (cation distribution) is one of the important factors in addition to doping elements, type of preparation methods, the condition of sintering temperature decides the changes in properties of ferrites [6].

Lithium ferrites have many applications in electrical, magnetic and microwave components as different ways such as circulators, memory cores, Phase shifters isolators, filters, oscillators, gyrators, in microwave latching devices, as core materials of inductors, transformer cores, as memory devices in computers, cathode material in rechargeable lithium batteries. The present study is useful to study the diaelectical properties for fabrication of capacitors, as microwave, devices as pulse mode application devices and transformer cores. The wide applications of the lithium ferrites as a microwave devices due totheir high resistivity and very less dielectric loss. Stoichiometric ferrites containing no Fe^{2+} ions and Non- stoichiometric ferrites (sintered above 1000^{o}C) contains Fe^{3+} ions and Fe^{2+} ions causes low resistivity.

The resistivity of ferrites increases by adding appropriate substituent ions minimizing Fe^{2+} ions and also leads to improving magnetic properties and minimizing eddy current loss in transformers. The conduction mechanism in ferrites is also important for electrical properties explains on the basis of hoping electrons between F^{2+}ions and Fe^{3+} ions which are occupied in tetrahedral sites in spinel ferrites and also causes polar on the radius and impurity conduction. Method of preparation, sintering time, Sintering temperature with the rate of heating and cooling influences the rapid change in electrical properties [7-8]. The aim of the present study is to observe the different parameters which are influences on dielectric behavior.

EXPERIMENTAL DETAILS

Lithium ferrite samples with compositional formula [$Li_{(1+3y)/2}Mo_yFe_{2.5-5y/2}$] O_4: where y=0.05 to 0.5, in steps of 0.05 were prepared by solid- state reaction method. Appropriate proportions AR grade Li_2Co_3, MoO_3, Fe_2O_3 were taken in an agate mortar and thoroughly ground for two hours then methanol added again ground until dried mixture. The dried mixture was pre-fired at 625^{o}C for 4 hrs in the programmable furnace with an air atmosphere. After pre-fired the powder was ground again until granulated by adding a small amount of PVA binder. For making pellets, the granulated powder was compressed uniaxially under pressure 5tones/cm^2 with help of electrical pressing machine using steel die. The pellets sample were finally sintered at1200^{o}C for 4 h for obtaining dense material especially at higher concentration and cooled in an air atmosphere at the rate of 3^{o}C/min. At these temperatures, oxygen dissociation and lithium volatility occur resulting in formation Fe^{2+} ions [9]. DC electrical properties were measured using two probe methods with help of Kiethly model 614electrometer. Dielectric constant and loss factor were studied using impedance analyzer: HP 4192A LFT.

RESULTS AND DISCUSSIONS

The compositional variation of dielectric constant at 1 KHz of molybdenum substituted lithium ferrites can be shown in figure.1. From the figure the dielectric constant is initially increased to y= 0.1 then decreases up to y=0.15 from where increases to y=0.25 from where maintain constant up to then to y=0.40 then decreases finally with continuation increases of composition(y). The variation in dielectric constant can be explained on the basis of space charge polarization due to in homogeneous structure as suggested by the Maxwell [10] and Wagner [11-12]. Space charge polarization is governed by two factors (1) The number of space charge carriers and (2) the resistivity of the sample. Iwauchi [13] reported that there is an existing strong correlation between dielectric behavior and conduction mechanism in ferrites. The dielectric constant with frequency variation almost follows the similar to the compositional variation. The observed variation of dielectric constant with frequency can be attributed to the space charge polarization, which is due to an inhomogeneous dielectric structure as discussed by Maxwell [14]. The decrease in dielectric constant (ϵ^1) with increasing frequency is normal behavior spinel ferrites and can be attributed to the number of available Fe^{2+} ions at octahedral sites. The variation of dielectric constant with frequency is shown in Figure.2.

The variation of dielectric loss tangent (tanδ) with frequency for Mo^{6+}ferrite series is given in Figure. 3. The compositional variation of dielectric loss for molybdenum series is increased up to y = 0.40 then decreases which are higher values at lower frequencies (≈ 1KHz) due to the fact that hopping frequency produces a maximum dielectric loss at room temperature. All the ferrite samples are shows low dielectric loss which values are below one at higher frequencies and these are useful for microwave applications.

The conduction mechanism in these ferrites (n-type) is considered as the hopping of the electrons between Fe^{2+} and Fe^{3+} over the octahedral site. Therefore, a maximum in tanδ is observed when the hopping frequency is approximately equal to that of the externally applied field [15].

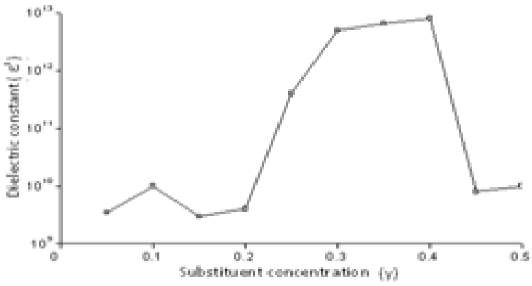

Figure 1: Variation of Dielectric Constant (ε′) with Molybdenum Substituent Concentration at 1 KHZ

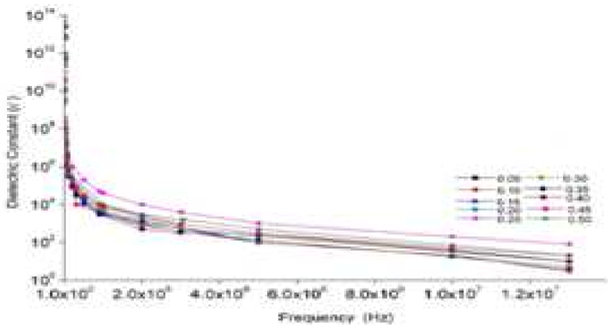

Figure 2: Variation of (ε′) with Frequency (f) for the System [Li $_{(1+3y)/2}$Mo$_y$Fe$_{2.5-5y/2}$]O$_4$

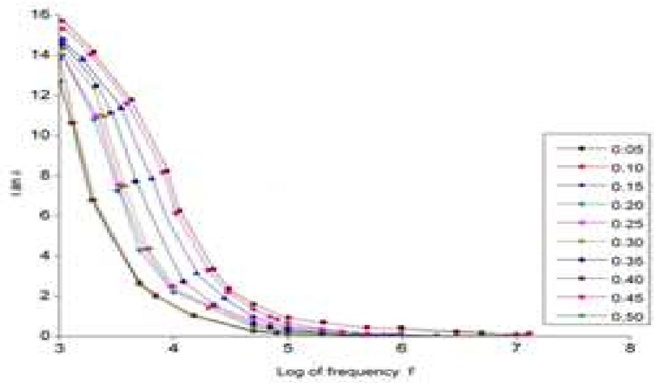

Figure 3: Variation of Dielectric Loss Tangent (Tan δ) Versus Log F for [[Li $_{(1+3y)/2}$Mo$_y$Fe$_{2.5-5y/2}$]O$_4$ of Ferrites

CONCLUSIONS

The dielectric behavior of Mo^{6+} substituted lithium ferrites was studied systematically with compositional variation and frequency response of all samples up to 10MHz. In compositional variation were studied at 1 KHz it shows that the dielectric constant initially increases at y=1.0 then decreases to y= 0.15 then increases up to y=0.25 from where maintain constant up to y=0.40 then decreases finally with continues increasing compound due to the fact that space charge polarization. The similar trend follows at dielectric constants also which are low values at high frequencies i.e. lies in

between 55-60. The dielectric loss of all samples shows high value at smaller frequencies (≈ 1 KHz) and very less value (less than one) at higher frequencies which is explained on hopping frequency.

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